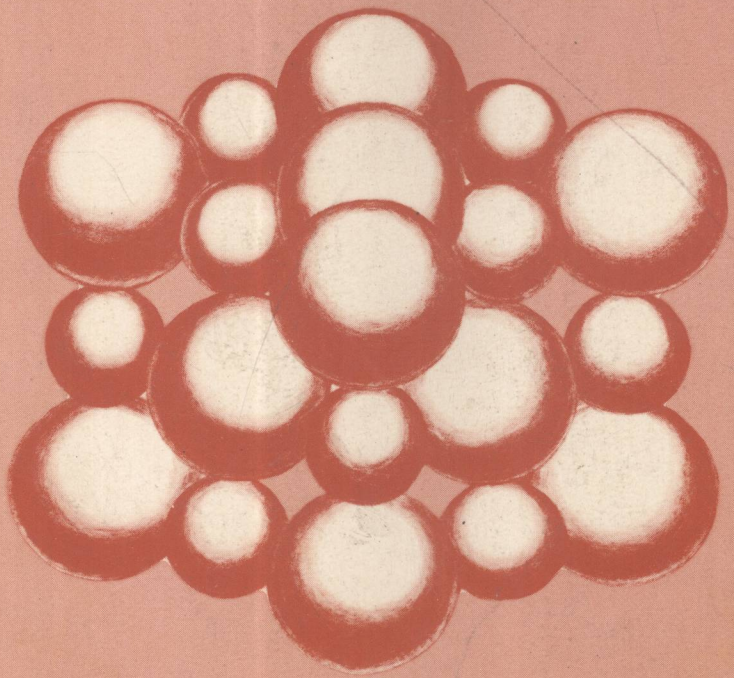
Student Self-Study Guide

Fundamentals of Chemistry



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Preface

The purpose of this study guide is to serve as a silent tutor that will help you master some of the basic principles of chemistry. It accompanies Fundamentals of Chemistry, by Karl Kumli. The sequence of chapters and topics in this guide is identical to that of the textbook.

Use this guide as you would use any tutor. A tutor can help you learn a subject only if you help yourself. First, there is no substitute for a lecturer or instructor. The instructor represents your major contact with the subject, directing your study through lectures and discussions and evaluating your progress in the course. The primary requirement in any course is that you attend all of the lectures, discussions, and laboratories. To prepare for the lectures, read over the material to be discussed, note those points that seem difficult, and formulate questions about what you do not understand. After the lecture, reread those sections of the text that have been covered in lecture and work problems. Since this course is meant to help you improve your ability to handle the quantitative aspects of chemistry, the more problems you work, the better.

This study guide is designed to help you through the more difficult parts of the textbook. Each chapter of the study guide contains the following: a list of

learning objectives for each chapter of the text; a list of important terms and concepts with references to the section of the text in which they are discussed; a set of problems similar in nature to those discussed in the text; detailed solutions for these problems; short self-tests over each chapter with answers for the test.

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Contents

CHAPTER 1	Introduction	1
CHAPTER 2	Math Review and Scientific Measurements	3
CHAPTER 3	Matter and Energy	22
CHAPTER 4	Atomic Structure	31
CHAPTER 5	The Periodic Table	45
CHAPTER 6	Chemical Bonds Between Atoms	58
CHAPTER 7	Stoichiometry, The Quantitative Aspects of Chemical Reactions	74
CHAPTER 8	The Behavior of Gases	93
CHAPTER 9	Liquids and Solids	110
CHAPTER 10	Solutions	123
CHAPTER 11	Aqueous Solutions of Acids, Bases, and Salts	139
CHAPTER 12	Rates of Reactions and Chemical Equilibrium	161
CHAPTER 13	Oxidation-Reduction Reactions	173

chapter

1 Introduction

As the title states, this chapter is simply a narrative introduction to science in general and chemistry specifically.

OBJECTIVES

1. From this chapter you should begin to develop a vocabulary of chemical terms and learn precise meanings for each of these terms. (Sections 1.1, 1.2, and 1.3)
2. You should develop an initial plan of study for this course. (Section 1.6)

IMPORTANT TERMS AND CONCEPTS

SECTION 1.1

Science the knowledge of facts, phenomena, laws, and proximate causes of a subject gained and verified by exact observations, organized experiments, and critical thinking.

SECTION 1.2

Scientific method the method of the acquisition of knowledge that involves observation, correlation, prediction, and verification.

Inductive reasoning the process of development of assumptions from a collection of facts.

Hypothesis assumptions made from observed facts.

Theory assumptions explaining observations which have been verified by such a large number of facts that they are almost irrefutable.

SECTION 1.3

Chemistry the science that studies matter, the transformation of matter and the energy changes accompanying these transformations.

Matter anything that has mass and occupies space.

QUESTIONS AND PROBLEMS

SECTION 1.2

1. Relate the discovery of atmospheric pressure described in this section to the scientific method.

Answer:

1. Observation of Facts
   Water rises only 34 feet in a vacuum.
   Mercury rises only 30 inches in a vacuum.
   Air has mass.
   The height of mercury in a Torricelli tube varies from day to day.

   Hypothesis
   The weight of the air of the atmosphere pushes the water and the mercury into the vacuum.

   Verification
   The height of mercury in a Torricelli tube decreases as the altitude increases or as the weight of atmospheric air decreases.

chapter

2 Math Review & Scientific Measurements

In this chapter, you should review all of the simple mathematical operations, the use of negative numbers, the use of exponential numbers, the use of scientific notation, the use of logarithms, the solving of simple equations, and the use and interpretation of graphs. You should learn the International System of Measurements and the Metric System of Measurements.

OBJECTIVES

1. After completing the math review, you should be able to work all of the problems of addition, subtraction, multiplication, and division using a pocket calculator (Section 2.1).
2. You should be able to perform all of the arithmetical manipulations which involve negative numbers (Section 2.2).
3. You should be able to solve simple first order equations for a given unknown (Section 2.3).
4. You should be able to work with all exponential numbers and perform the arithmetical operations using exponential numbers (Section 2.4).
5. You should be able to perform the following operations with scientific notation of numbers: (It is okay if you use a scientific pocket calculator.)
   a. Convert decimal numbers to scientific notation.
   b. Convert scientific notation to decimal numbers.
   c. Add, subtract, multiply, and divide numbers expressed in scientific notation (Section 2.5).
6. You should be able to express any number as a logarithm or convert a logarithm to a natural number (Section 2.6).

7. You should be able to plot and interpret line graphs of two variables that are functions of each other (Section 2.7).
8. You should know the common Metric and SI prefixes for decimal multiples and fractions (Section 2.8).
9. You should know the common units of measurement for length, volume, and mass in the International and Metric Systems (Section 2.8).
10. You should know approximate comparisons between the Metric or SI units of mass, length, and volume to similar units of the U.S. Customary System (Section 2.10).
11. You should be able to set up solutions for simple word problems by means of dimensional-unit analysis (Section 2.9).
12. You should be able to use conversion factors and dimensional-unit analysis to convert a given measurement from the U.S. Customary System to the Metric System or vice versa (Section 2.10).
13. You should know the relationship between common U.S. Customary units and metric units.
14. You should be familiar with the common tools of measurement of mass and volume (Section 2.11).
15. When you record a measurement, you should know how many significant figures to use (Section 2.11).
16. You should be able to determine the allowable number of significant figures for an answer in arithmetical operations using significant figures (Section 2.11).
17. You should be able to convert temperature readings between the Fahrenheit, Celsius, and Kelvin scales (Section 2.12).
18. You should know the meaning of density (density is the ratio of the mass of a body to its volume) and be able to express the definition as an algebraic equation. $\left(\text{density} = \frac{\text{mass}}{\text{volume}}\right)$ (Section 2.13).
19. Given any two of the measurements, density, mass, or volume, you should be able to determine the third. (Remember to use dimensional-unit analysis to set up or check your solution.) (Section 2.13)

IMPORTANT TERMS AND CONCEPTS

SECTION 2.4

Exponents the number placed as a superscript following a base number which indicates the number of times the base number is to be multiplied by itself

or in the case of a fractional exponent the root the base number is to be reduced to.

SECTION 2.5

Scientific notation the convention of expressing a number as a decimal number between 1 and 10 multiplied by 10 raised to an exponential power to give the appropriate magnitude.

SECTION 2.6

Logarithms the exponential power to which a base number (commonly 10) must be raised to be equal to a given number.

SECTION 2.10

Conversion factor the ratio of two equivalent quantities of measure having different units that is equal to unity (1).

SECTION 2.12

Temperature the condition of a body which determines the transfer of heat to or from another body.

Absolute zero the theoretical temperature at which all molecular motion ceases. It is assigned the value of 0 K or $-273.15^{\circ}C$.

SECTION 2.13

Density the ratio of the mass of a body of matter to the volume of the body.

Specific gravity the ratio of the mass of a body of matter to the mass of an equal volume of a standard substance, usually water for liquids and solids.

QUESTIONS AND PROBLEMS

MATH REVIEW

1. Perform the following indicated addition or subtraction of fractions:

a. $\frac{5}{9} + \frac{2}{3} =$ b. $\frac{2}{3} + \frac{2}{7} =$ c. $\frac{5}{2} + \frac{3}{4} + \frac{2}{3} =$

d. $\frac{1}{2} + \frac{5}{6} + \frac{3}{7} + \frac{2}{3} =$ e. $\frac{a}{b} + \frac{c}{d} =$ f. $\frac{a}{b} + \frac{b}{a} =$

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g. $\frac{2}{3} - \frac{1}{2} =$ h. $\frac{4}{5} - \frac{2}{3} =$ i. $\frac{4x}{y} - \frac{2}{z} =$

j. $\frac{a}{c} - \frac{a}{b} =$

Answers:

1. To add or subtract fractions, they are converted to fractions with a common denominator and only the numerators are added or subtracted.

   a. The common denominator of 9 and 3 is 9

   $$\frac{5}{9} + \frac{2}{3} = \frac{5}{9} + \frac{6}{9} = \frac{11}{9}$$

   b. $\frac{20}{21}$

   c. The common denominator of 2, 4, and 3 is 12

   $$\frac{5}{2} + \frac{3}{4} + \frac{2}{3} = \frac{30}{12} + \frac{9}{12} + \frac{8}{12} = \frac{47}{12}$$

   d. $\frac{102}{42}$

   e. $\frac{a}{b} + \frac{c}{d} = \frac{ad}{bd} + \frac{cb}{bd} = \frac{ad + bc}{bd}$

   f. $\frac{a^2 + b^2}{ab}$

   g. $\frac{2}{3} - \frac{1}{2} = \frac{4}{6} - \frac{3}{6} = \frac{1}{6}$ h. $\frac{2}{15}$

   i. $\frac{4x}{y} - \frac{2}{z} = \frac{4xz}{yz} - \frac{2y}{yz} = \frac{4xz - 2y}{yz}$ j. $\frac{ab - ac}{cb}$

2. Multiply the following fractions as indicated:

   a. $\frac{1}{3} \times \frac{3}{4} =$ b. $\frac{5}{7} \times \frac{3}{8} =$ d. $\frac{a}{b} \times \frac{b}{c} =$

   e. $\frac{a}{d} \times \frac{2d}{b} \times \frac{b}{3c} =$

Answers:

2. a. $\frac{1}{\cancel{3}} \times \frac{\cancel{3}}{4} = \frac{1}{4}$ b. $\frac{5}{7} \times \frac{3}{8} = \frac{15}{56}$ d. $\frac{a}{\cancel{b}} \times \frac{\cancel{b}}{c} = \frac{a}{c}$

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e. $\frac{a}{\not d} \times \frac{2\not d}{\not b} \times \frac{\not b}{3c} = \frac{2a}{3c}$

(Note: When there are identical terms in the numerator and the denominator of a series of multiplications, they cancel. This is an important procedure in using dimensional-unit analysis or the factor-label method of solving problems.)

3. Perform the indicated division of fractions:

a. $\frac{3}{4} \div \frac{2}{3} =$ b. $\frac{7}{12} \div \frac{7}{9} =$

c. $\frac{4x}{5y} \div \frac{x}{5} =$ d. $a \div \frac{4a}{c} =$

Answers:

3. a. $\frac{3}{4} \div \frac{2}{3} = \frac{3}{4} \times \frac{3}{2} = \frac{9}{8}$ b. $\frac{7}{12} \div \frac{7}{9} = \frac{7}{12} \times \frac{9}{7} = \frac{9}{12} = \frac{3}{4}$

c. $\frac{4x}{5y} \div \frac{x}{5} = \frac{4\not x}{\not 5 y} \times \frac{\not 5}{\not x} = \frac{4}{y}$ d. $a \div \frac{4a}{c} = \not a \times \frac{c}{4\not a} = \frac{c}{4}$

SECTION 2.1

Solve the following problems using a scientific pocket calculator.

4. a.
2175
3962
8431
5257

b.
375
4695
1237
3841

c.
2656
8912
3726
6996

d. 1479 - 765 + 5927 - 3747 =

e. 8492 - 6557 + 7483 - 4176 =

f. 5280 ÷ 941 x 375 =

g. 84 479 x 245 ÷ 362 + 419 =

Answers:

a. 19 825 b. 10 148 c. 22 290 d. 2894
e. 5242 f. 2140 g. 136.4

SECTION 2.2 Negative Numbers

5. Perform the following additions:

   a. $5 + (-2) + (+6) + (-10) =$

   b. $-273 + (-40) + (-60) =$

   c. $4x + 4 + (2x - 2) =$

   d. $5 + (-2) + x + (-6x) =$

6. Perform the following subtractions:

   a. $-40 - (-273) =$ b. $-10 - (-32) =$

   c. $-7x - (-3x) =$ d. $(6x + 10) - (4x - 16) =$

7. Perform the indicated multiplications and divisions:

   a. $(-2)(+6)(-4) =$ b. $(-x)(-4)(-5) =$

   c. $(4x)(-y)(x - y) =$ d. $144 \div (-6) =$

Answers:

5. In the addition of negative numbers: (i) if all of the numbers are negative the sum is negative; (ii) if the signs of the two numbers are different, the difference is taken and the sign of the larger number is retained.

   a. -1 b. -373 c. $6x + 2$ d. $3 - 5x$

6. In the subtraction of negative numbers, the sign of the number is changed and the two numbers are added algebraically.

   a. $-40 - (-273) = -40 + 273 = 233$

   b. $-10 - (-32) = -10 + 32 = 22$ c. $-4x$

   d. $(6x + 10) - (4x - 16) = 6x + 10 - 4x + 16 = 2x + 26$

7. In multiplication and division, if an even number of negative numbers are multiplied or divided the product or the quotient is positive; if an odd number of negative numbers are multiplied or divided, the product or quotient is negative.

   a. +48 b. $-20x$ c. $-4x^2y + 4xy^2$ d. -24

SECTION 2.3 Solving Equations

8. Solve: $xy + a = 7$ for x

9. Solve: $d = \frac{m}{v}$ for v

Answers:

8. Isolate the term containing x on the left of the equation by subtracting a from each side:

$$\begin{array}{r} xy + a = 7 \\ -a \qquad -a \\ \hline xy \quad = 7 - a \end{array}$$

   Divide both sides of the equation by y

$$\frac{xy}{y} = \frac{7 - a}{y}$$

$$x = \frac{7 - a}{y}$$

9. $d = \frac{m}{v}$

   Multiply both sides by v

$$d \times v = \frac{m}{v} \times v$$

$$d \times v = m$$

   Divide both sides by d

$$\frac{d \times v}{d} = \frac{m}{d}$$

$$v = \frac{m}{d}$$

SECTION 2.4 Exponents

10. Write the following in exponential form:

a. $(2)(2)(2)(2)(2) =$ b. $\frac{1}{7} \times \frac{1}{7} \times \frac{1}{7} \times \frac{1}{7} =$

c. $(y)(y)(y)(y)(y)(y)(y) =$

11. Solve the following:

a. 6^5 b. 2^{-6} c. $81^{1/4}$

d. $36^{3/2}$ e. 10^{-3} f. 8^0

12. Solve the following multiplications and divisions:

a. $x^3 \cdot x^2 =$ b. $(y^4)(y^{-6}) =$

c. $(y^2)(y^2)(y^3) =$ d. $x^3 \div x^2 =$

e. $y^{-4} \div y^3 =$ f. $m^{-5} \div m^{-8} =$

13. Solve the following:

a. $(y^3)^2 =$ b. $(x^8)^{1/4} =$ c. $(y^3)^{4/3} =$ d. $(y)^0$

Answers:

10. a. 2^5, a number times itself a series of times may be written as the number followed by a superscript showing the number of times it is to be multiplied by itself; the superscript is called an exponent.

b. 7^{-4}, a fraction written in an exponential form may be written as the reciprocal of the fraction to the negative power.

c. y^7

11. a. $6 \times 6 \times 6 \times 6 \times 6 = 7776$

b. $2^{-6} = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{64}$

c. $81^{1/4} = \sqrt[4]{81} = 3$, a number to a fractional power is the number to the root of the demoninator.

d. $36^{3/2} = (\sqrt{36})^3 = (6)^3 = 216$

e. $10^{-3} = \frac{1}{1000} = 0.001$

f. $8^0 = 1$, any number to the zero power is equal to 1.

12. a. x^5 , when exponential numbers are multiplied, the exponents are added.

b. y^{-2} c. y^7

d. x , when exponential numbers are divided, the exponent of the divisor is subtracted from the exponent of the dividend.

e. y^{-7} f. m^3

13. a. y^6 , when an exponential number is raised to a power, the exponent of the number is multiplied by the power.

b. x^2 c. y^4

d. $y^0 = 1$, any number to the 0 power is equal to 1.

SECTION 2.5 Scientific Notation

14. Express the following numbers in scientific notation:

a. 1 576 000 b. 3 724.6

c. $825 000 000 d. 2 470 000 000

e. 5 280 f. 224 000

g. 0.000 293 h. 0.000 000 006 75

i. 0.017 j. 0.000 049 6

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